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PSEUDO-ALGAL NODULES IN THE GREENFIELD DOLOMITE (UPPER SILURIAN OF OHIO)

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The Greenfield dolomite is the basal member of the Bass Island formation of the Upper Silurian Monroe division. The type locality is in the vicinity of Greenfield, northeastern Highland County, Ohio. It has been described by Carman[1] as a "drab, fine-grained dolomite with carbonaceous partings and commonly in beds of 2–6 inches, although at places with thicker beds or massive ledges. This massive phase is rough textured and vesicular, with corals and stromatoporoids, . . ." The thickness is not accurately known, but it is presumed to be between 75 and 100 feet.

In the old, and now abandoned, Rucker quarry, just east of Greenfield and across the line in Ross county, 53 feet of the Greenfield are exposed[2] in what may be considered the type exposure. Here are exhibited many interesting sedimentary rock structures such as mud-cracks, ripple-mark, stylolites, "cup-and-cone" concretions, and near the top of the section is a conglomeratic layer from 5 to 30 inches thick composed in places of rounded or flat pebble-like dolomitic nodules loosely cemented by dolomitic limestone (text figures 1 and 2). These nodular bodies are the special concern of these remarks.

They were first mentioned in print in 1871 by Edward Orton[3], who speaks of "a layer of concretions, from one to three inches in diameter, near the upper part of the section [in the Rucker quarry]." In 1915, Bownocker[4] located the layer in the massive 5-foot course six feet below the top of the exposure, and noted that it contained "a profusion of well rounded limestone pebbles, usually about an inch in diameter," and that "these resulted from wave action when the locality was at or near a shore line." The latest notice of them was in 1917 by Napper[5] who remarked that when broken the nodules show a concentric structure. Beyond these scattering and sketchy allusions the writer has failed to find other mention of these peculiar structures. His attention to them was drawn by Dr. J. E. Carman, and he was struck by their outward resemblance to the well-known "water-biscuits" of Squaw Island at the northern end of Canandaigua Lake, central New York[6], and to similar nodules formed by algal agency in fresh and brackish

[1]Carman, J. E., 1927, "The Monroe Division of Rocks in Ohio," *Jour. Geol.*, Vol. 35, p. 486.

[2]Bownocker, J. A., 1915, "Building Stones of Ohio," *Geol. Surv. Ohio, 4th Ser., Bull.* 18, p. 43.

[3]Orton, E., 1871, "The Geology of Highland County," *Geol. Surv. Ohio, Progress Rep. for 1870*, p. 290.

[4]Bownocker, J. A., *op. cit.*, p. 44.

[5]Napper, C. W., 1917, "Concretionary Forms in the Greenfield Limestone," *Ohio Jour. Sci.*, Vol. 18, p. 11.

[6]Clarke, J. M., 1903, "The Water Biscuit of Squaw Island, Canandaigua Lake, N. Y., *54th Ann. Rep. N. Y. State Mus.*, 1902, Vol. 3, pp. 195–198, pls. 13–15.

Fig. 1—A

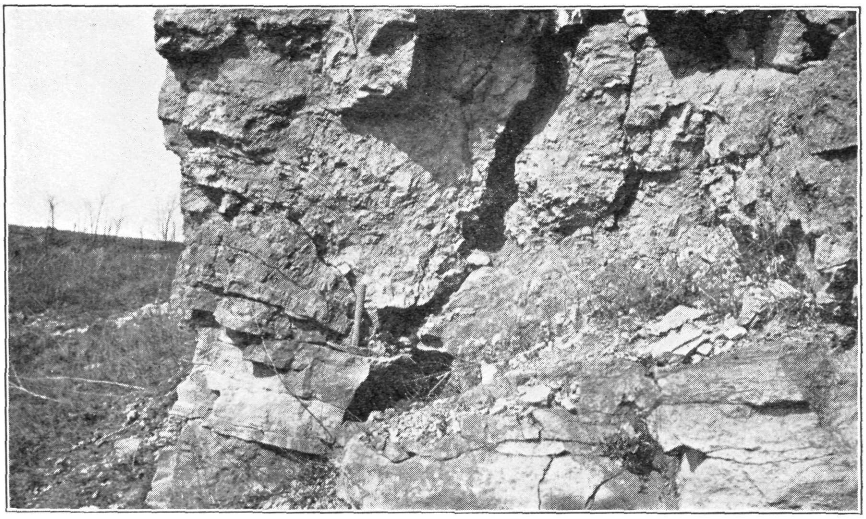


Fig. 1—B

Fig. 1. Zone of pseudo-algal nodules in the Greenfield dolomite, near top of east wall of old Rucker Quarry, east of Greenfield, Ohio: *a*, Base of hammer handle is just below a pocket of nodules; *b*, Nodular zone to left and right of hammer, with non-bedded dolomite with scattered patches of nodules, above and below, and with regularly-bedded dolomite at bottom and top. (Length of hammer, 15 inches.)

waters in many other localities, and which have been reported from many geologic horizons from Pre-Cambrian to Recent.

EXTERNAL FORM AND OCCURRENCE OF THE NODULES

They vary in shape and in size from nearly spherical balls 2 to 5 cm. in diameter (Plate I, Fig. 8) to flat, shingle-like pebbles from 2 to 6 cm. across and up to 1 cm. in thickness (Plate I, Fig. 9). The rounded ones frequently show one or more flat, subfacetted surfaces, as if they had been packed together in a plastic condition, and are simply agglomerated with more or less porous or fragmental dolomitic limestone between them. The flattened pebbles usually show a definite orientation, overlapping each other and often steeply inclined in the same manner as the flat pebbles on shingle beaches and shallow bottoms, athwart the general direction of wave motion and inclined in the direction whence it came, the whole mass constituting a sort of edge-wise conglomerate.

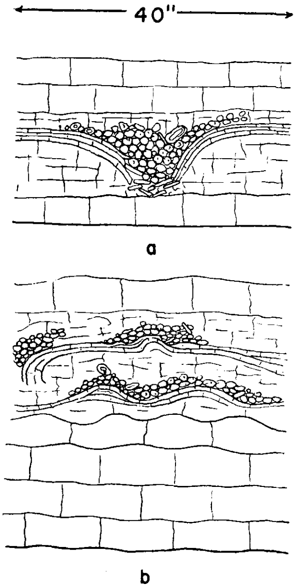


Fig. 2. Diagrammatic sketches of nodular zone in the Greenfield dolomite, old Rucker Quarry, east of Greenfield, Ohio: *a*, Area above hammer in Fig. *1a; b*, Area to right of hammer in Fig. *1b*.

STRUCTURE OF THE NODULES

The rounded nodules, as revealed by thin sections, are composed of concentrically arranged laminae of closely aggregated dolomite granules arranged about an irregularly shaped nucleus which is often a fragment of the same laminar material, or a very porous dolomitic mass of coarse granules (Plate I, figs. 1, 4). The lamination is strongly marked by narrow yellowish-brown limonitic bands which are darker than the prevailing drab tone of the nodules. In one ovoid specimen the nucleus was but half-filled with spongy dolomite, the rest being a plano-convex cavity with drusy calcite crystals. The limonitic bands appear in places as sharply defined continuous, or rarely discontinuous dark lines (Plate I, Fig. 2), in others as vague pale stainings of the dolomitic granules. An average nodule measuring 22 x 35 mm. in diameters has a porous nucleus 3 x 12 mm., with three strongly-marked dark laminae about 0.5 mm. think and from 2 to 5 mm. apart. Between each of the dark layers are from 10 to 15 thinner, finer ones, frequently forming distinct laminae separated from each other by open lenticular spaces partly filled with drusy calcite (Plate I, Fig. 4). The heavier laminae are usually circumferentially continuous, but the thinner intermediate ones may merge laterally with the ones above or below them, especially where they pass around the end of the longer axis. Many of the bands show a sharp peripheral boundary and grade centrally into the light zones.

The flat, shingle-like nodules show the same concentric banded structure, but with fewer open lenticular spaces and more even and regular lamination (Plate I, Fig. 10). The nucleus of each is a fragment of rock, a bit of broken-up stratum having the same laminated structure and averaging 7 mm. in thickness. The lower laminae of the nuclei are flat and undisturbed, but the upper ones (comprising about two-thirds of the thickness of the nucleus) form a zone of contorted layers with many cavities, as if the contortion occurred just before or simultaneously with the breaking up of the stratum, perhaps by subaqueous solifluction.

That the deposition of the concentric laminae around these fragments took place before the latter were re-arranged in their present situation, probably by wave-action, is shown by the separation of the coated fragments from each other by several layers of concentric laminae. The upper part of the layer of shingled pieces is covered by 15 to 50 mm. of laminae like those of the rounded and flat nodules and the nuclei of the latter, and which at first follow the irregular edges of the fragments closely but which slowly even out with the uppermost laminae only slightly undulant. This later deposit binds the shingled layer together fairly well and its general aspect is that of the physico-chemical encrustations on algal masses described by Bradley[7] in these terms:

> They resemble layers of algal deposit in thinning and in places wedging out on the steep or overhanging sides of dome-shaped protuberances, but unlike the algal deposits many continue as thin encrustations into the bottoms of pocket-like depressions or infolds and up the sides of the adjoining excrescences. Furthermore they differ from layers that are patently algal in tending toward a simpler surface form where many are superimposed. They fill the invaginations between algal colonies and bridge gaps between them, and above such bridges each succeeding layer becomes more uniform in thickness and so smooths out the surface contour.

COMPARISON WITH NODULES OF ALGAL ORIGIN

The criteria for the distinction of structures due to algal agency from those resulting from physico-chemical processes are not well-defined and can scarcely be said to have received much attention in print, especially for such cases as the present one where later diagenetic changes have occurred. However, comparison of the Greenfield nodules with authentic algal structures is of service in an attempt to discern their origin.

The shape of the more nearly spherical nodules and their gross concentric internal structure is strongly suggestive of algoid balls, but their microscopic character does not show features associated with known algal agencies, such as the minute spherical shells of the unicellular *Chlorellopsis*,[8] the fine, loose tubules of such

[7] Bradley, W. H., 1929, "Algal Reefs and Oolites of the Green River Formation," *U. S. Geol. Surv. Prof. Paper* 154, p. 209.

[8] Bradley, *op. cit.*, pl. 32.

EXPLANATION OF PLATE I

ALGAL AND PSEUDO-ALGAL NODULES

Fig. 1. Cross-section of rounded nodule from the Greenfield dolomite with porous nucleus, × 1.

Fig. 2. Part of same specimen showing uniformity of the laminae, × 7.

Fig. 3. Part of same specimen showing lenticular drusy cavities between laminae, × 7.

Fig. 4. Cross-section of rounded nodule from the Greenfield dolomite, with fragment of laminated dolomite as nucleus, × 1.

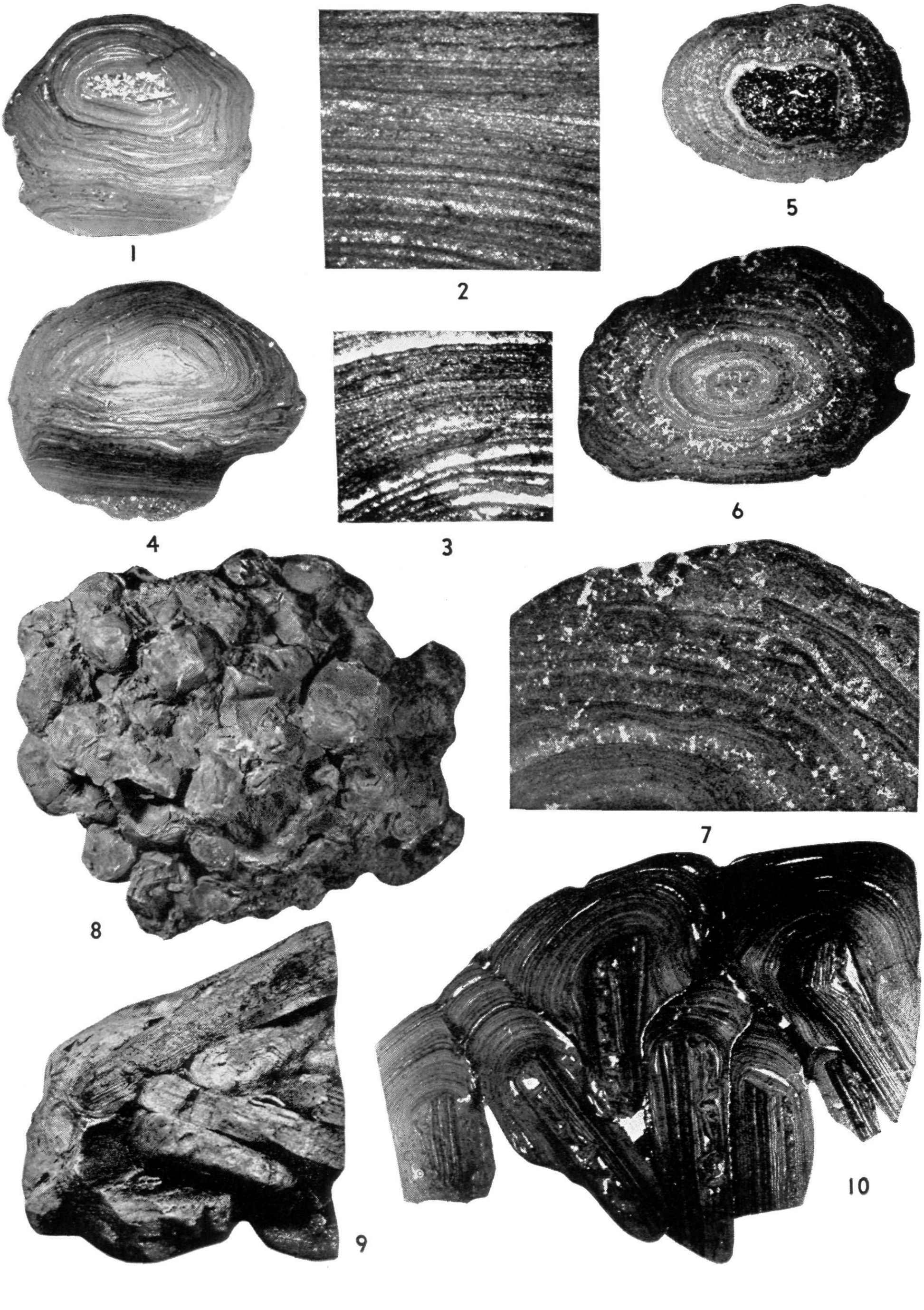
Figs. 5 and 6. Cross-section of *Zonotrichites* nodules from Upper Cretaceous fresh-water beds, Willow Creek, east of Redmond, Sevier County, central Utah, collected by E. M. Spieker, × 1. The nucleus of Fig. 5 is a fragment of pink rhyolite.

Fig. 7. Cross-section of *Zonotrochites* nodule (see Fig. 6) showing characteristic pseudomorphous calcareous algal deposits, × 2.3.

Fig. 8. Conglomerated rounded nodules from the Greenfield dolomite, × 0.4, (O. S. U. Geol. Mus. No. 9868).

Fig. 9. Shingled flat nodules from the Greenfield dolomite, viewed in plane of bedding, × 0.66.

Fig. 10. Section of right end of specimen in preceding figure, viewed across bedding plane, × 1.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porostromatids as *Sphaerocodium*, *Ortonella*, *Mitcheldeania*, and *Girvanella*, nor the close-packed prismatic tubules of the rhodophycean *Solenopora*, nor the undulant spongy microcrystalline layers of less determinable pseudomorphous forms with faint tubular molds of filamentous algae such as the recent "water biscuits" of Canandaigua Lake and other localities, the "ooids" described by Eardley[9] from the Flagstaff formation (Eocene) of Utah, and the nodules of *Zonotrochites* from the European Rhaetic figured by Bornemann[10]. Thin sections of nodules illustrative of this pseudomorphous type (*Zonotrichites*) are figured on Plate I, Figs. 5–7[11].

Nor are the Greenfield nodules like some of the less authentic, but none-the-less probable algal structures which formed similar masses,—the "stromatoliths," such as the famous *Cryptozoon* of the Cambrian and Ordovician, some specimens of which, however, do show faint traces of tubular molds[12], and *Ottonosia*[13], from the Pennsylvanian of the mid-continent area, in which there may be tubular molds and in which the nodular form of the sharply-defined but very irregularly discontinuous laminae does not smooth out upwards.

Against these evidences of lack of correspondence with known algal structures, we have only the point that the laminae of the Greenfield nodules do not show the radial fibrous structure of physico-chemical encrustations, but such structure, if ever present, may well have been obliterated by the subsequent dolomitization. On the other hand, the uniformity of the laminations, both laterally and vertically, as contrasted with the irregular and undulant laminations[14] of genuine algal deposits, the absence of definite calcareous algal structures such as tubules, and the lack of pseudomorphous spongy layers with tubular molds, are all suggestive of inorganic deposition.

CONCLUSION

The nodules found in the Greenfield dolomite at its type locality near Greenfield, Ohio, show no traces of structures attributable either directly or indirectly to algae and are thought to be the result of physico-chemical deposition.

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[9]Eardley, A. J., 1932, "A Limestone Chiefly of Algal Origin in the Wasatch Conglomerate, Southern Wasatch Mountains, Utah." *Papers Michigan Acad. Sci., Arts, and Letters*, Vol. 16, pl. 32.

[10]Borneman, J. G., 1887, "Geologische Algenstudien," *Jahrb. Preuss. Geol. Landes, für* 1886, pl. 5, fig. 1.

[11]Specimens from Upper Cretaceous fresh-water deposits in Utah, collected by Dr. E. M. Spieker, to whom the writer is indebted not only for these specimens but also for others from the Upper Jurassic and the Eocene of the same state.

[12]Goldring, W., 1938, "Algal Barrier Reefs in the Lower Ozarkian of New York . . ." *N. Y. State Mus. Bull.* No. 315, fig. 14 *et al.*

[13]Twenhofel, W. H., 1919, "Pre-Cambrian and Carboniferous Algal Deposits," *Amer. Jour. Sci.*, Vol. 198, p. 348.

[14]Bradley (*op. cit.*, p. 218) states in connection with the laminated algal deposits in the Green River formation that "they are arcuate [and] considerably different from the fibrous incrustation of acicular crystals, . . . much less uniform, . . . vary rapidly in thickness from place to place, and their upper surfaces are very irregular and serrate, not smooth like the layers in agate structure."